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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/784,903	02/20/2004	A. Farid Issaq	ACT-390	6148

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EXAMINER	
NADAV, ORI	

ART UNIT	PAPER NUMBER
2811	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

TH

Office Action Summary	Application No.	Applicant(s)	
	10/784,903	ISSAQ ET AL.	
	Examiner	Art Unit	
	Ori Nadav	2811	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *04 April 2007*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1,3-35,40 and 42-46* is/are pending in the application.

4a) Of the above claim(s) *35* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1,3-34,40 and 42-46* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1, 13, 16, 23 and 29 are rejected under 35 U.S.C. 103(a) as being unpatentable over McCollum (5,789,764) in view of Takagi et al. (5,550,400) and Shan et al. (6,906,421).

Regarding claims 1 and 23, McCollum teaches in figure 7C and related text a reprogrammable metal-to-metal antifuse comprising:

a lower metal interconnect layer 82;

an inter-metal dielectric layer 84 disposed over said lower metal interconnect layer, said inter-metal dielectric layer having a via formed there through and filled with a metal plug 88;

a lower adhesion-promoting layer 90 disposed over said lower metal layer;

an antifuse material layer 92 disposed above an upper surface of said lower adhesion-promoting layer, said antifuse material layer selected from a group comprising at least one of amorphous carbon and amorphous carbon doped with at least one of hydrogen and fluorine disposed over said lower adhesion-promoting layer;

and an upper adhesion-promoting layer 94 disposed over said antifuse material layer.

McCollum does not teach lower and upper Ti barrier layers disposed under and over said upper adhesion-promoting layers, and said lower adhesion-promoting layer and said upper adhesion-promoting layer each with a thickness of between about 2 angstroms and about 20 angstroms.

Shan et al. teach adhesion-promoting layers having a thickness of between about 10 angstroms and about 200 angstroms (abstract).

Takagi et al. teach in figure 2 lower and upper Ti barrier layer and lower and upper adhesion-promoting layers 20, 8 (Ti/TiN) disposed under and over an antifuse.

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to use lower and upper Ti barrier layer and lower and upper adhesion-promoting layers (Ti/TiN) under and over the antifuse each with a thickness of between about 2 angstroms and about 20 angstroms in McCollum's device in order to improve the adhesion and the protection of the layers in the device and to reduce the size of the device, respectively.

Regarding claims 13, 16 and 29, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to use said antifuse material layer having a thickness of between about 50 angstroms and about 500 angstroms, in McCollum's device in order to optimize the device characteristics according to the requirements of the application in hand.

Claims 14-15 and 30-31 are rejected under U.S.C. 103(a) as being unpatentable over McCollum, Takagi et al. and Shan et al., as applied to Claims 1, 13, 16, 23 and 29, and further in view of Liu et al. ("A New Metal-to-Metal Antifuse with Amorphous Carbon," IEEE Electron Device Letters, Vol. 19, No. 9, (1998), pp. 317 - 319). McCollum, Takagi et al. and Shan et al. teach substantially the entire claimed structure, as applied to claims 1-2, 13, 16, 23 and 29 above, except an antifuse material layer doped with hydrogen in a concentration range of about 1 atomic percent to about 40 atomic percent.

Liu et al. disclose (p. 317, right side, first paragraph) that amorphous carbon is used with hydrogen and fluorine doping as an antifuse element. It would have been obvious to one of ordinary skill in the art at the time of the invention to use an antifuse material layer doped with hydrogen in a concentration range of about 1 atomic percent to about 40 atomic percent in prior art's device in order to reduce ON-OFF switching and leakage currents (Liu et al., page 318, left side, 2nd paragraph, page 319, conclusion).

Claims 1, 3, 6-8, 11-17, 20-22, 29 and 34 are rejected under U.S.C. 103(a) as being unpatentable over Forouhi (5,181,096) in view of Liu et al. and Shan et al. Regarding claims 1, 3, 6-8, 11-12, 14-1, 17, 20-22 and 34, Forouhi teaches in figure 1 and related text a reprogrammable metal-to-metal antifuse comprising:

a lower metal interconnect layer 16;

a lower Ti barrier layer 18 disposed over said metal layer;

a lower silicon nitride adhesion-promoting layer 20 disposed over said lower Ti barrier layer;

an antifuse material layer 22 disposed above an upper surface of said lower adhesion-promoting layer and lower Ti barrier layer,

an upper silicon nitride adhesion-promoting layer 24 disposed over said antifuse material layer; and

an upper Ti barrier layer 28 disposed under and over said upper adhesion-promoting layer.

Forouhi does not teach said antifuse material layer selected from a group comprising at least one of amorphous carbon and amorphous carbon doped with at least one of hydrogen and fluorine, and said lower adhesion-promoting layer and said upper adhesion-promoting layer each with a thickness of between about 2 angstroms and about 20 angstroms.

Liu et al. teach an antifuse material layer selected from a group comprising at least one of amorphous carbon and amorphous carbon doped with at least one of hydrogen and fluorine.

Shan et al. teach adhesion-promoting layers having a thickness of between about 10 angstroms and about 200 angstroms (abstract).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to use an antifuse material layer selected from a group comprising at least one of amorphous carbon and amorphous carbon doped with at least one of hydrogen and fluorine, and said lower adhesion-promoting layer and said upper

adhesion-promoting layer each with a thickness of between about 2 angstroms and about 20 angstroms, in McCollum's device in order to improve the characteristics of the device, and to reduce the size of the device, respectively.

The combination is motivated by the teachings of Liu et al. who point out the advantages of using an antifuse material layer comprising an amorphous carbon over an antifuse comprising silicon nitride and amorphous silicon.

Regarding claims 13, 16 and 29, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to use said antifuse material layer having a thickness of between about 50 angstroms and about 500 angstroms, in prior art's device in order to optimize the device characteristics according to the requirements of the application in hand.

Claims 23-24 and 27-32 are rejected under U.S.C. 103(a) as being unpatentable over Forouhi, Liu et al. and Shan et al., as applied to claims 1 and 14-15 above, and further in view of McCollum

Forouhi, Liu et al. and Shan et al. teach substantially the entire claimed structure, as applied to claims 1-2 and 14-15 above, except an inter-metal dielectric layer disposed over said lower metal interconnect layer, said inter-metal dielectric layer having a via formed there through and filled with a metal plug.

McCollum teaches in figure 7C and related text an inter-metal dielectric layer 84 disposed over said lower metal interconnect layer, said inter-metal dielectric layer having a via formed there through and filled with a metal plug 88;

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to use an inter-metal dielectric layer disposed over said lower metal interconnect layer, wherein said inter-metal dielectric layer having a via formed there through and filled with a metal plug in prior art's device in order to use the device in a practical application.

Claims 4-5, 9-10, 18-19 and 33 are rejected under U.S.C. 103(a) as being unpatentable over Forouhi, Liu et al. and Shan et al., as applied to claims 1 and 3 above, and further in view of Han (6,583,953).

Forouhi, Liu et al. and Shan et al. teach substantially the entire claimed structure, as applied to claims 1 and 3 above, except adhesion-promoting layers comprising SiC.

Han teaches in figure 4 and related text an adhesion-promoting layer comprising SiC (column 4, lines 21-24).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to use an adhesion-promoting layers comprising SiC in prior art's device in order to improve the device characteristics. Note that substitution of materials is not patentable even when the substitution is new and useful. Safetran Systems Corp. v. Federal Sign & Signal Corp. (DC NIII, 1981) 215 USPQ 979.

Claims 25-26 are rejected under U.S.C. 103(a) as being unpatentable over Forouhi, Liu et al., McCollum and Shan et al., as applied to claim 23 above, and further in view of Han.

Forouhi, Liu et al., McCollum and Shan et al. teach substantially the entire claimed structure, as applied to claims 1 and 3 above, except adhesion-promoting layers comprising SiC.

Han teaches in figure 4 and related text an adhesion-promoting layer comprising SiC (column 4, lines 21-24).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to use an adhesion-promoting layers comprising SiC in prior art's device in order to improve the device characteristics. Note that substitution of materials is not patentable even when the substitution is new and useful. Safetran Systems Corp. v. Federal Sign & Signal Corp. (DC NIII, 1981) 215 USPQ 979.

Claims 40 and 42-46 are rejected under 35 U.S.C. 103(a) as being unpatentable over Forbes (6,674,667).

Regarding claim 40, Forbes teaches a method for programming and erasing a reprogrammable metal-to-metal antifuse, comprising:

programming said antifuse by applying a programming potential across said antifuse to cause a programming current to flow through said antifuse until its resistance substantially decreases (figure 6 and related text);

erasing said antifuse by applying an erasing potential across said antifuse, said erasing potential being lower in magnitude than said programming potential and causing an erase current to flow through said antifuse, and

reprogramming said antifuse by applying a programming potential across said antifuse to cause a programming current to flow through said antifuse until its resistance substantially decreases (inherent), wherein said erasing step is successful if said antifuse has been returned to a high-resistance state (inherent).

Forbes does not explicitly state that reprogramming said antifuse occurs after said erasing step is successful.

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to reprogram Forbes's antifuse after said erasing step is successful in order to obtain the correct information when reprogramming.

Regarding claims 43 and 46, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to include soaking said antifuse by passing a soak-current through said antifuse, and applying a potential having a more negative value above said antifuse material layer, in Forbes's device in order to operate the device in its intended use.

Regarding claims 42 and 44-46, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to use a programming current in a range of between about 0.1 to about 1mA, wherein said soak-current has a magnitude of about

5mA, wherein said programming current is less than about 1mA and a ratio of said erase current to said programming current is about 10:1, and wherein a ratio of said erase current to said soak current is about 3:1 in Forbes's device in order to optimize the device operation.

Response to Arguments

Applicant argues that McCollum teaches away from the proposed modification, because McCollum teaches that the "barrier layer thicknesses are typically 2,000 angstroms thick, since their purpose is to prevent aluminum or other metals from the conductors from diffusing into the antifuse material layer." (Col. 12, lines 25-30). In this respect, McCollum actually teaches away from the minimization of the adhesion-promoting layers proposed by Examiner, as it stresses the importance of a thickness well outside the claimed "between about 2 angstroms and about 20 angstroms" range.

The examiner agrees that McCollum teaches that the adhesion promotion layer has a thicknesses of about 2,000 angstroms, in order to prevent aluminum or other metals from the conductors from diffusing into the antifuse material layer. However, although the above thickness is required for McCollum's device, said thickness is not necessarily required for the modified device of McCollum, Takagi et al. and Shan et al. The device of McCollum, Takagi et al. and Shan et al. includes barrier layers Ti/TiN. It is well known in the art that barrier layers Ti/TiN are used to improve the adhesion of the layers in the device and to prevent electro-migration in the device. Therefore, the

device of McCollum, Takagi et al. and Shan et al. does not require thick adhesion promotion layer to prevent aluminum or other metals from the conductors from diffusing into the antifuse material layer. An artisan would be well motivated to reduce the size of the adhesion promotion layer without running the risk of having aluminum or other metals from the conductors diffusing into the antifuse material layer.

Applicant argues that Forouhi teaches away from the proposed modification, because Forouhi teaches a dielectric layer thickness in the range of between about 50 to 300 angstroms. (Col. 5, lines 3-10).

Although Forouhi teaches a dielectric layer having a thickness in the range of between about 50 to 300 angstroms, an artisan would be motivated to reduce the thickness of said layer (see above argument).

Applicant argues that it would not have been obvious to one ordinarily skilled in the art to program and erase a reprogrammable metal-to-metal antifuse using the steps recited in claim 40 in order to operate the device in its intended use, because there is no evidence that the claimed limitation is disclosed in the prior art.

Although the references do not explicitly state "programming said antifuse by applying a programming potential across said antifuse to cause a programming current to flow through said antifuse until its resistance substantially decreases, and erasing said antifuse by applying an erasing potential across said antifuse, said erasing potential being lower in magnitude than said programming potential and causing an

erase current to flow through said antifuse", these limitations are inherent in prior art's device for the following reasons.

A device comprising an antifuse operates by applying a programming potential across the antifuse. This causes a programming current to flow through said antifuse until its resistance substantially decreases. The erasing of said antifuse is done by applying an erasing potential across said antifuse. The erasing potential must be lower in magnitude than said programming potential so that an erase current flows through said antifuse. Therefore, it would not have been obvious to one ordinarily skilled in the art to program and erase a reprogrammable metal-to-metal antifuse using the steps recited in claim 40 in order to operate the device in its intended use.

Conclusion

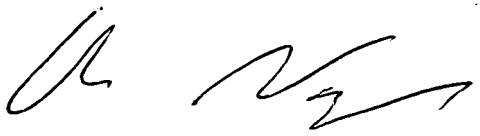
THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Ori Nadav whose telephone number is 571-272-1660. The examiner can normally be reached between the hours of 7 AM to 4 PM (Eastern Standard Time) Monday through Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Richard Elms can be reached on 571-272-1869. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).



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